Frequently Asked Questions Regarding Cassini's Earth Swingby

How can the probability of an Earth swingby reentry accident be so low?

The Cassini spacecraft has design requirements to ensure that the chance of an inadvertent reentry during Earth swingby are less that 1 in 1 million. To attain that goal JPL has conducted an in-depth analysis, which incorporated human error and historical JPL spacecraft data, to determine the probability of an inadvertent reentry. This analysis determined that the probability of an inadvertent Earth reentry is less than one in one million. The result is driven by two factors:

- For most of the trajectory the spacecraft will be nowhere near the Earth.
- A trajectory biasing strategy, coupled with redundant spacecraft system design, built-in fault detection and correction systems, and the ability to send commands to the spacecraft, lead to the exceedingly small probability of Earth impact.

The Cassini mission is being designed to ensure than an inadvertent swingby accident does not occur. Mission rules state that the chance of such an accident occurring must be less than one in one million. JPL has conducted an in-depth analysis, which incorporated human error and historical JPL spacecraft data, to determine the probability of an inadvertent reentry. This analysis determined that the probability of an inadvertent Earth reentry is less than one in one million. This result may be surprising to some people (at first) since it is difficult to prove that failures of any system, particularly spacecraft, can be that small. The result is driven by two factors.

First, for most of the Cassini trajectory it is very hard to hit the Earth. In fact, until about 50 days before Earth swingby, the probability of hitting the Earth is much less than 1 in a million regardless of the spacecraft failure (this is because of the vastness of space, the smallness of the Earth as a target, and the randomness of a spacecraft failure or micrometeoroid hit leading to a velocity change).

Second, JPL has "biased" the trajectory for Earth swingby. This scheme further limits the time and events that could cause inadvertent reentry by eliminating all failures except those that give the spacecraft the proper velocity magnitude and direction to impact the Earth. The spacecraft is biased 5,000 kilometers (3,106 miles) or more away from the swingby altitude (not less than 500 km) for all but 10 days prior to the swingby. The navigation accuracy of NASA spacecraft is better than 20 km. The biasing strategy effects, coupled with redundant spacecraft system design, built-in fault detection and correction systems, and controlled operation (via sending commands to the spacecraft), particularly during the limited time when failures could cause impact, lead to the exceedingly small probability of Earth impact.

In addition, these analyses are constantly being reviewed and refined, and revisions made in spacecraft design to ensure that the design requirement will not be exceeded.

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